

Study Results on Employing Virtual and Augmented Reality for Spacecraft Operations and Astronaut Training at ESOC and EAC

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Results of Studies for ESA EAC & ESOC
Performed by Terma GmbH & Fraunhofer IGD

Outline



- Practical
 - High-precision Model-based AR Tracking
 - Multi-modal AR Application for Rover Operation
 - VR for Astronaut Training
 - Integration of AR/VR with ESA Software
- Conceptual
 - Agile-like Workflow/Development Processes
 - Use Case Identification and Details Development
 - Use Case Ideas and Taxonomies

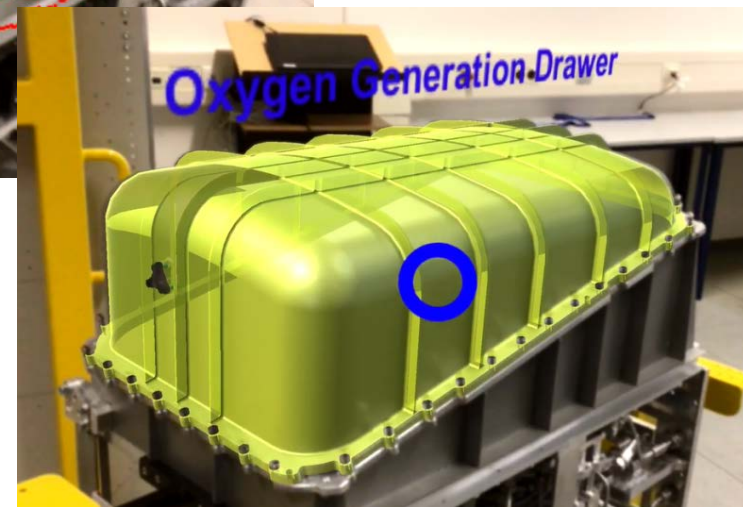
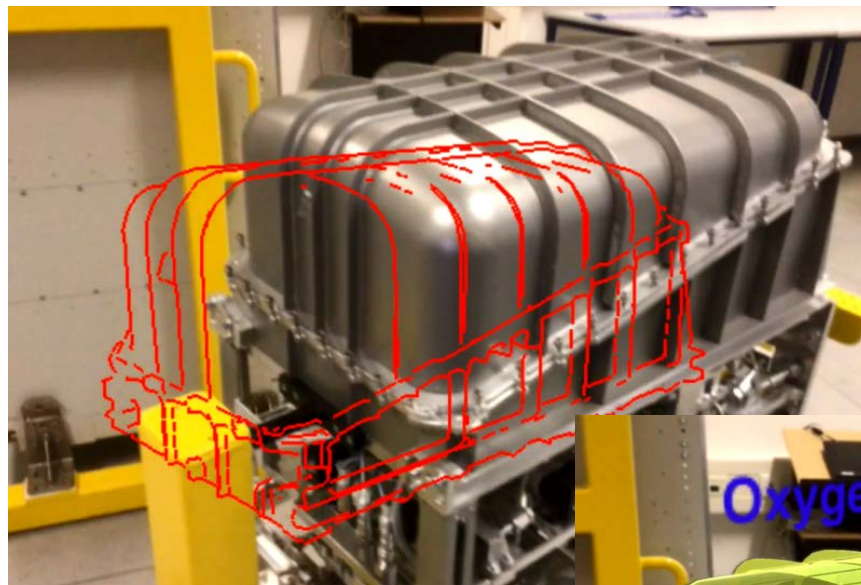
AR Tracking

- “HoloLens Tracking”
 - Track “Room”
 - Detect “Surfaces”
- Model-based Tracking
 - Track Objects
 - 3D-Model of Object
 - “Find Edges”
 - Initialisation
 - Tracking
 - VisionLib
(Fraunhofer IGD/
Visometry GmbH)

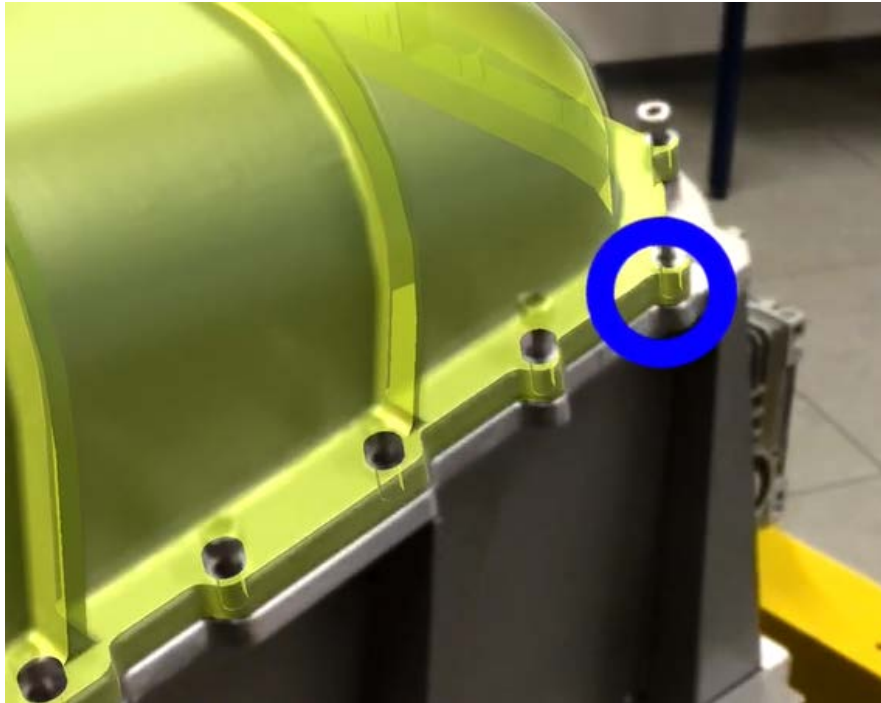


AR Tracking

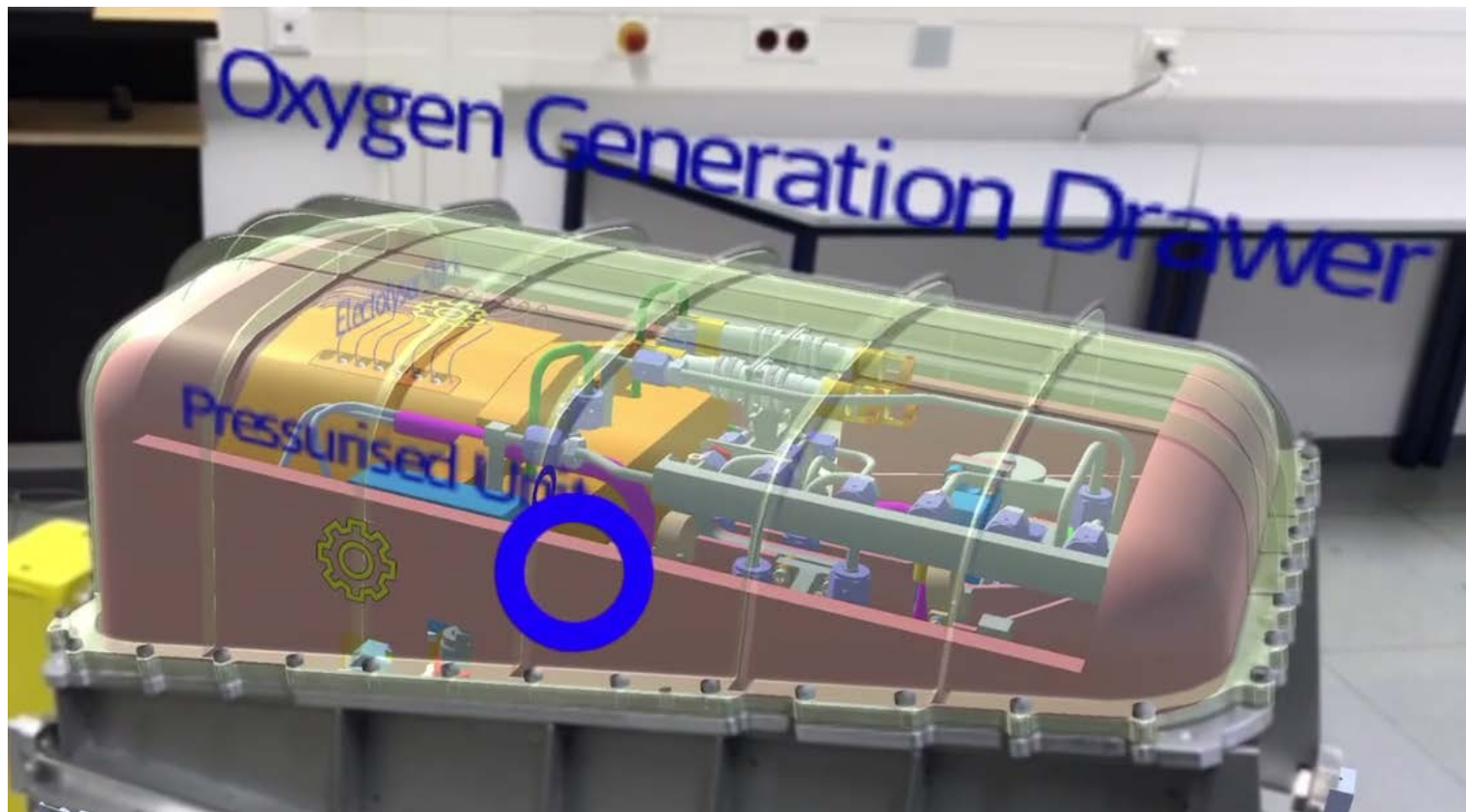
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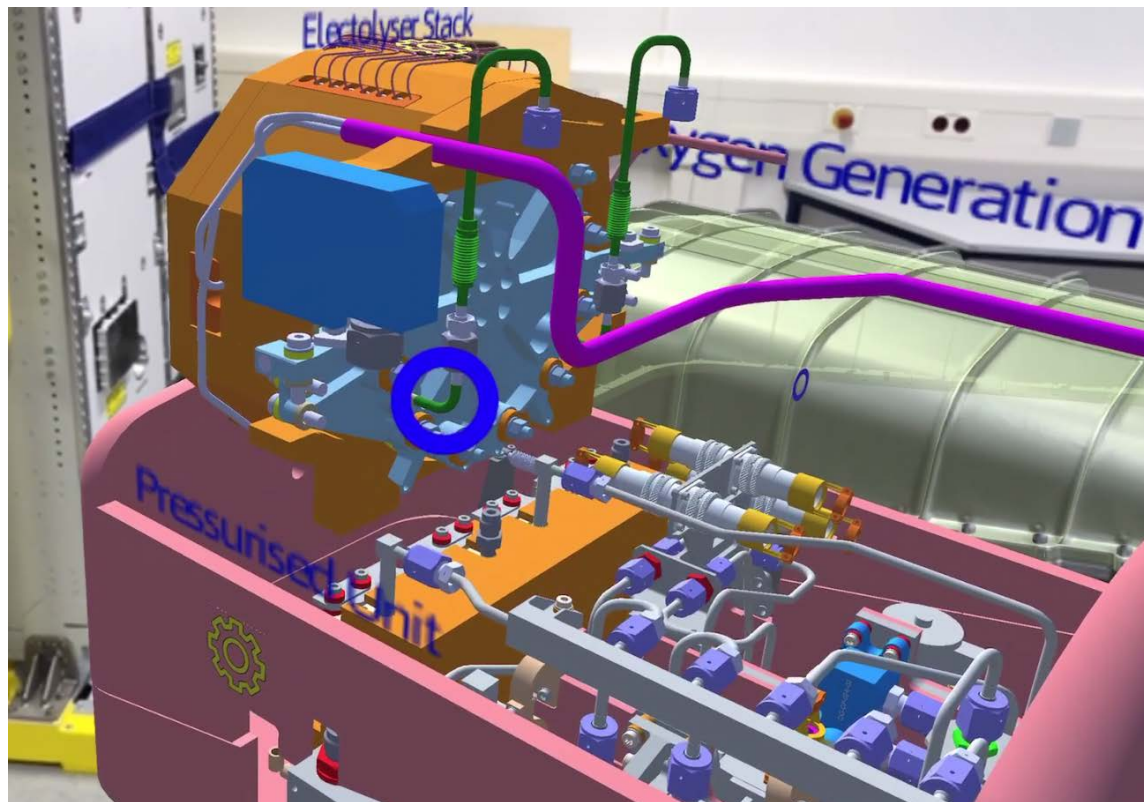
Interactive Training/Manual PoC – Tracking Precision

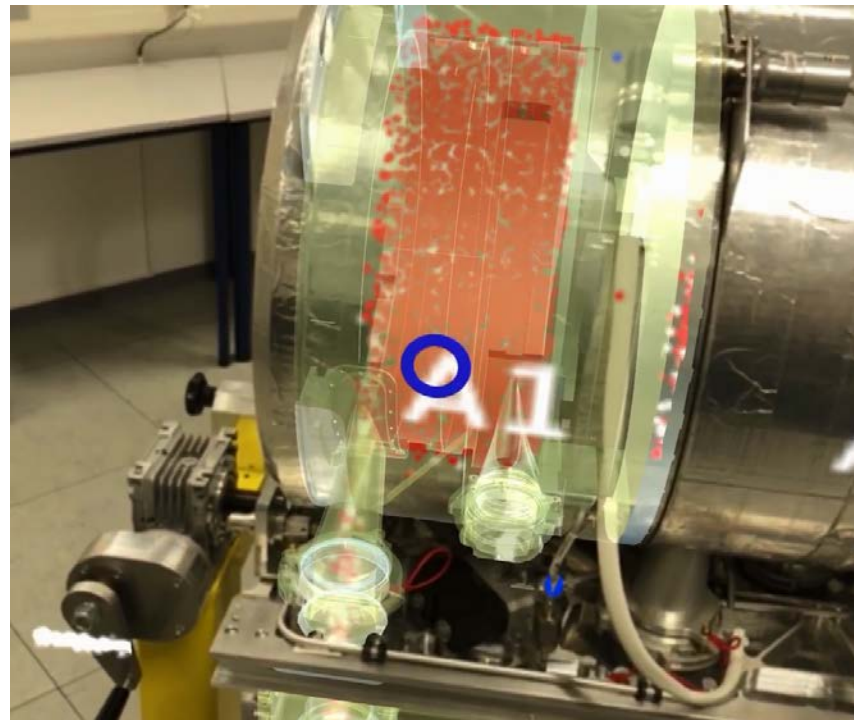


Interactive Training/Manual PoC – Visualisation



Interactive Training/Manual PoC – Visualisation





ESA, Terma GmbH, Fraunhofer IGD | 2019-12-02 | Slide 8



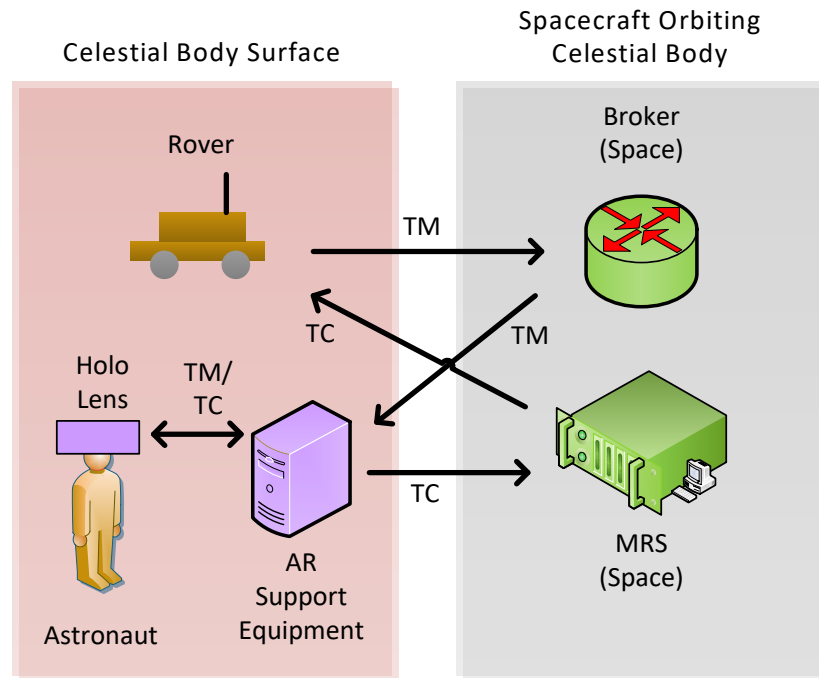
Multi-modal AR Application for Rover Operation

- **EAC**

- Astronaut & Rover on Celestial Body Surface
- Track Real Rover

- **ESOC**

- No Real Rover at AR User
- Virtual Rover Model & HoloLens Tracking
- Scalable View: Detail & Overview Display



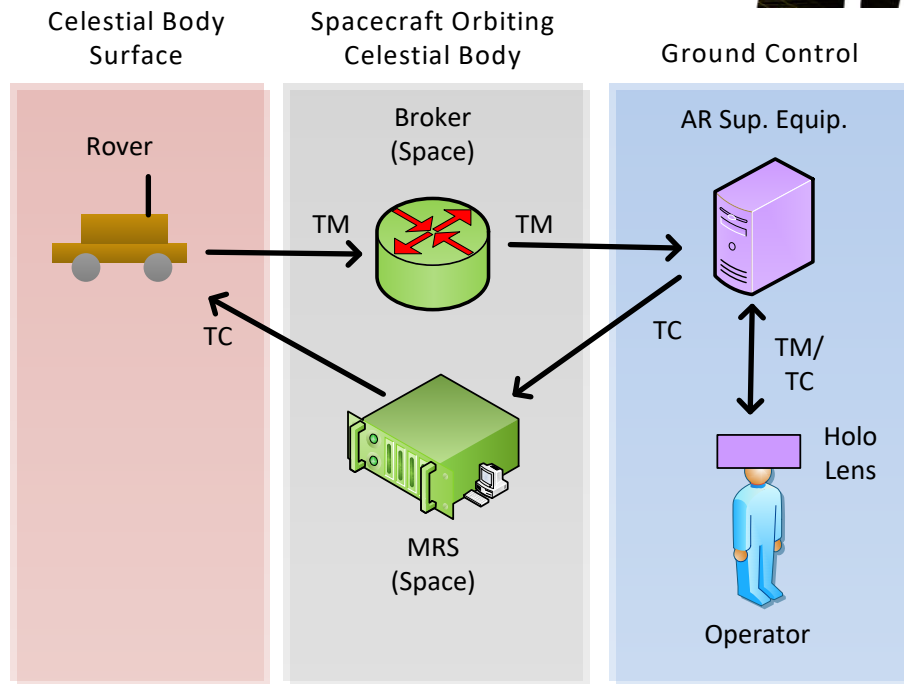
Multi-modal AR Application for Rover Operation

- **EAC**

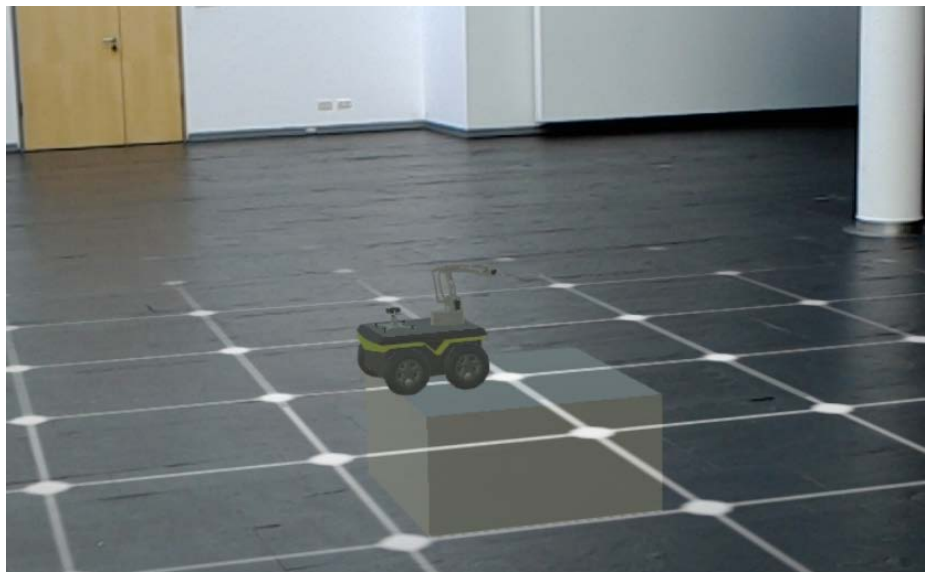
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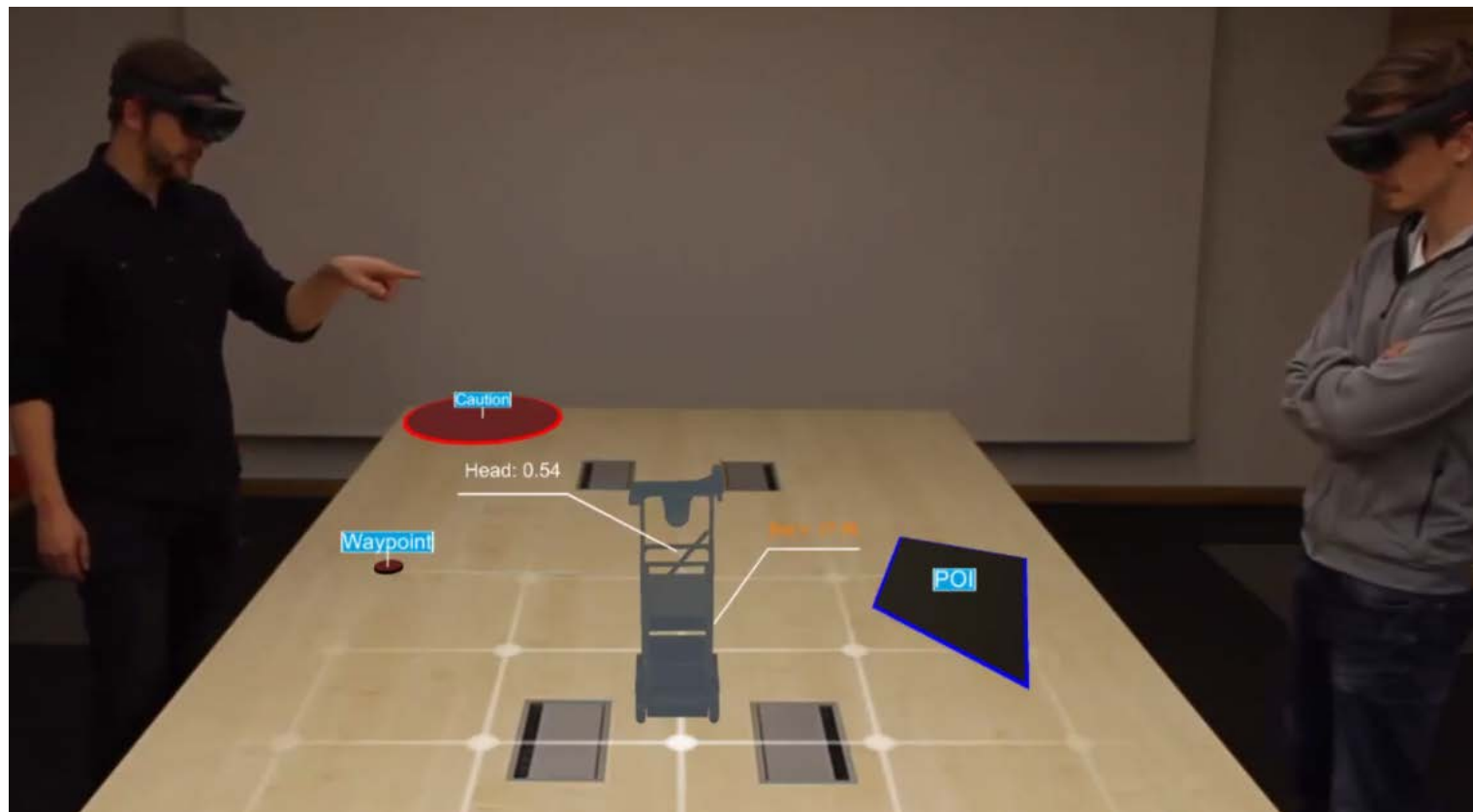
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Rover Operation Proof-of-Concept



Rover Operation Proof-of-Concept



VR for Astronaut Training

- **Virtual Lunar Base, Fire Emergency Training**

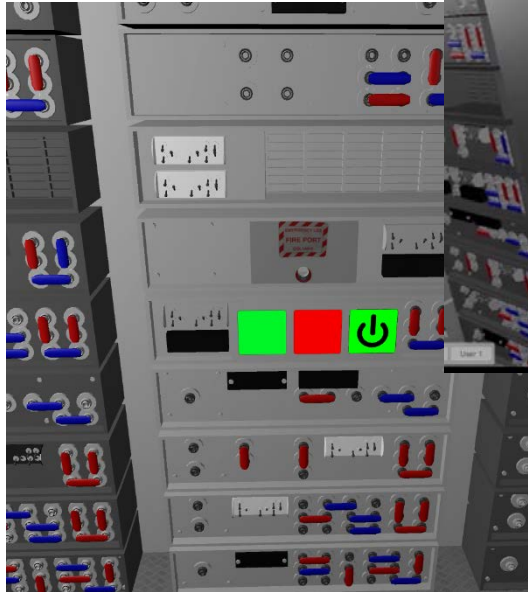
- Users/Roles

- Astronaut
- Operator
- Trainer



VR for Astronaut Training

- Virtual Lunar Base, Fire Emergency Training
- Users/Roles
 - **Astronaut**
Trainee, in VR
 - Operator
 - Trainer



VR for Astronaut Training



- Virtual Lunar Base, Fire Emergency Training

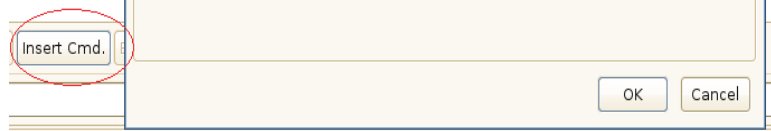
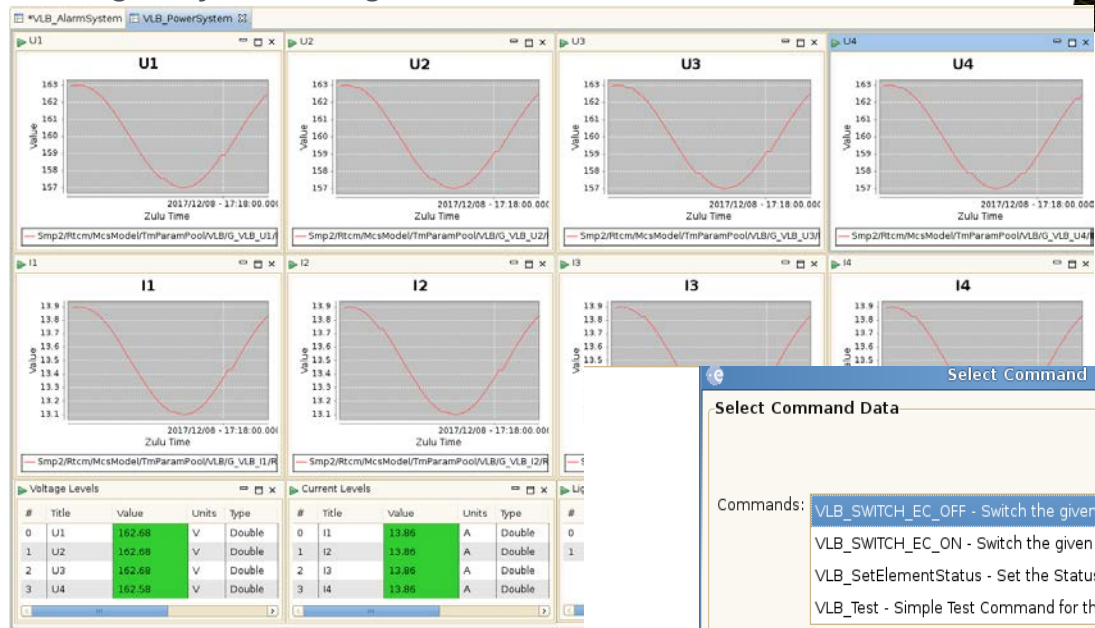
- Users/Roles

- Astronaut

- **Operator**

*Support Astronaut
via Mission Control
System*

- Trainer



VR for Astronaut Training

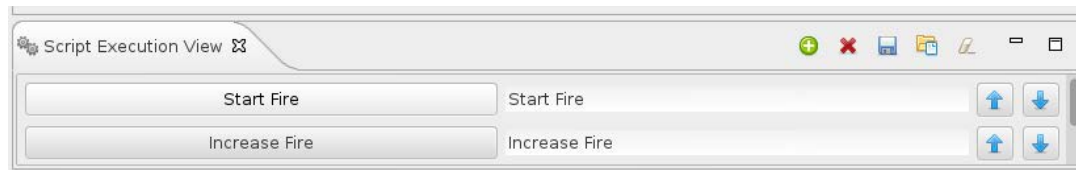


- Virtual Lunar Base, Fire Emergency Training

- Users/Roles

- Astronaut
- Operator
- **Trainer**

Prepare & Supervise Training

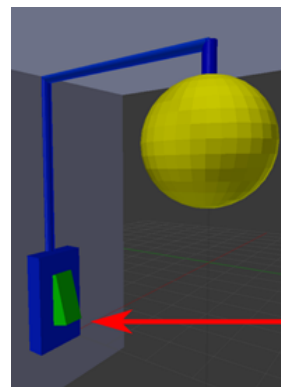
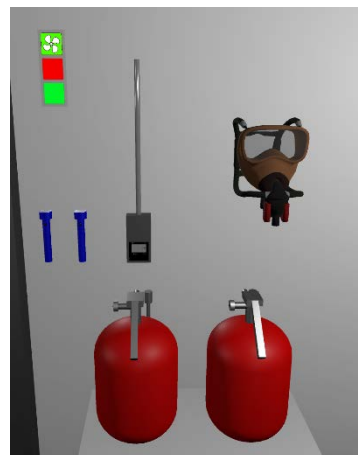
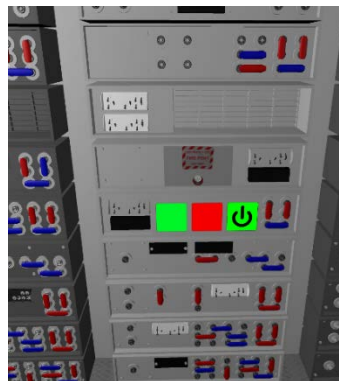


Simulation Inputs Outputs View					
Simulation Inputs			Simulation Outputs		
Name	Data Type	Data Path	Name	Data Type	Data Path
ElectricalCircuitStatus1	OCTET	GPGPU/lunar_base	FireAlarmStatus	OCTET[2]	GPGPU/lunar_base
ElectricalCircuitStatus2	OCTET	GPGPU/lunar_base	VentilationSystemStatus	OCTET[2]	GPGPU/lunar_base
ElectricalCircuitStatus3	OCTET	GPGPU/lunar_base	FireDeltaTemperature1	REAL	GPGPU/lunar_base
ElectricalCircuitStatus4	OCTET	GPGPU/lunar_base	FireDeltaTemperature2	REAL	GPGPU/lunar_base
ExtinguisherStatus1	OCTET	GPGPU/lunar_base	FireDeltaTemperature3	REAL	GPGPU/lunar_base
ExtinguisherStatus2	OCTET	GPGPU/lunar_base	FireDeltaTemperature4	REAL	GPGPU/lunar_base
ExtinguisherStatus3	OCTET	GPGPU/lunar_base	FireSeverity1	REAL	GPGPU/lunar_base



VR for Astronaut Training Models

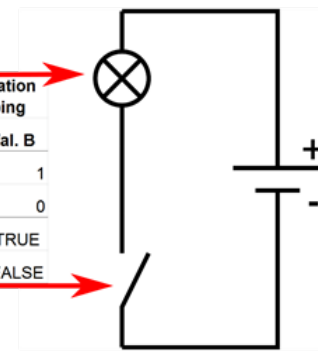
- Behavioural
 - MATLAB (Development)
 - SIMSAT (Run-time)
- 3D
 - Unity (Develop. & Run-time)
- Elements
 - Racks
 - Buttons, Status Display, ...
 - Fire Extinguishers
 - ...
- Model Integration
VR <-> Behavioural



VR Model

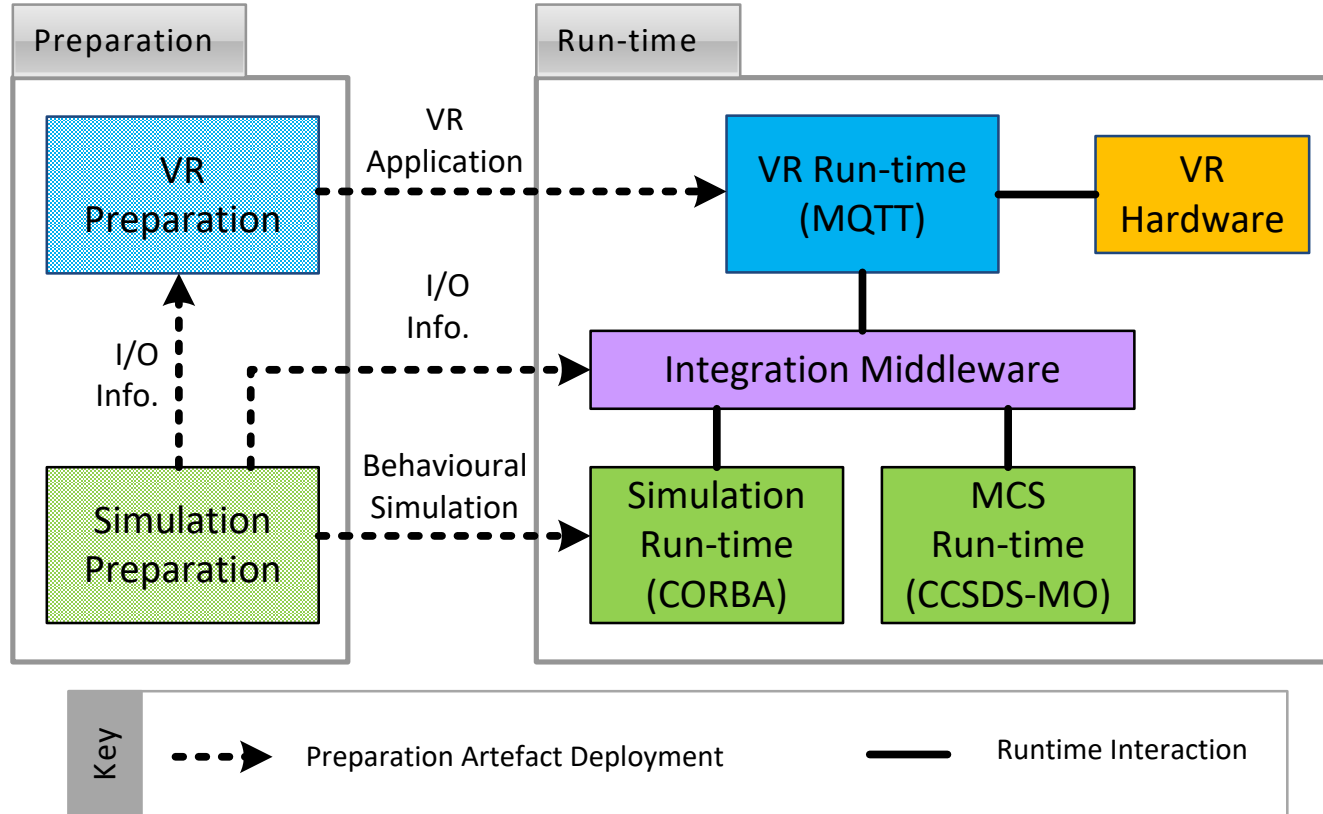
Translation Mapping					
Mod. A	El. A	Mod. B	El. B	Val. A	Val. B
vr1	Light	bh1	lamp	ON	1
				OFF	0
vr1	LighSw	bh1	switch	ON	TRUE
				OFF	FALSE

Interaction Mapping

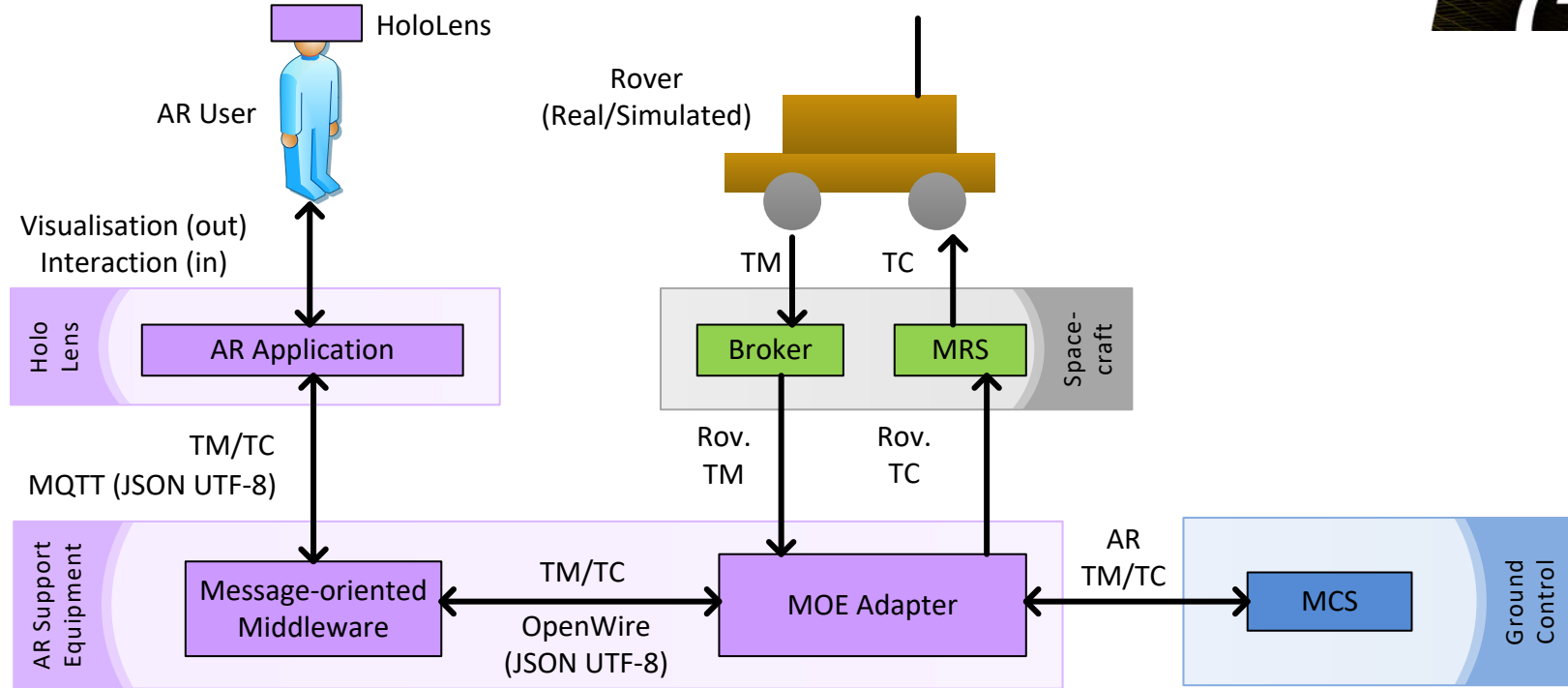


Behavioural Model

Integration of VR with ESA Software

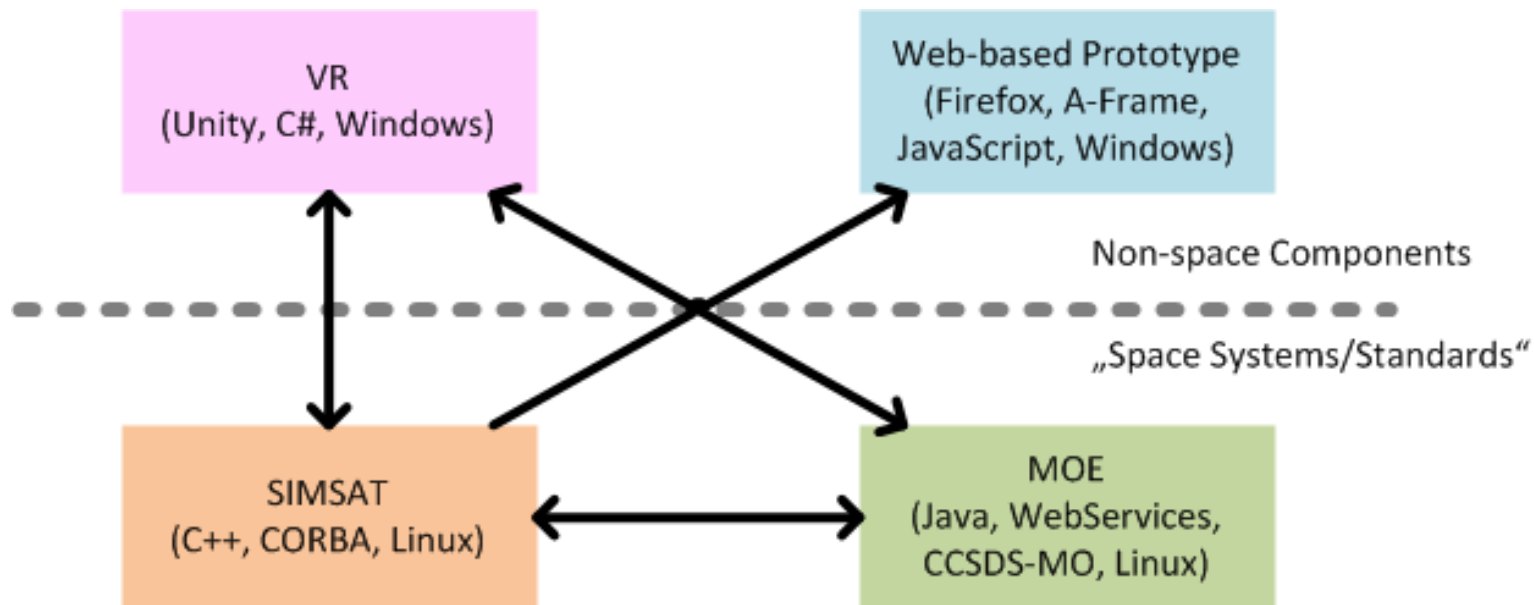


Integration of AR with ESA Software

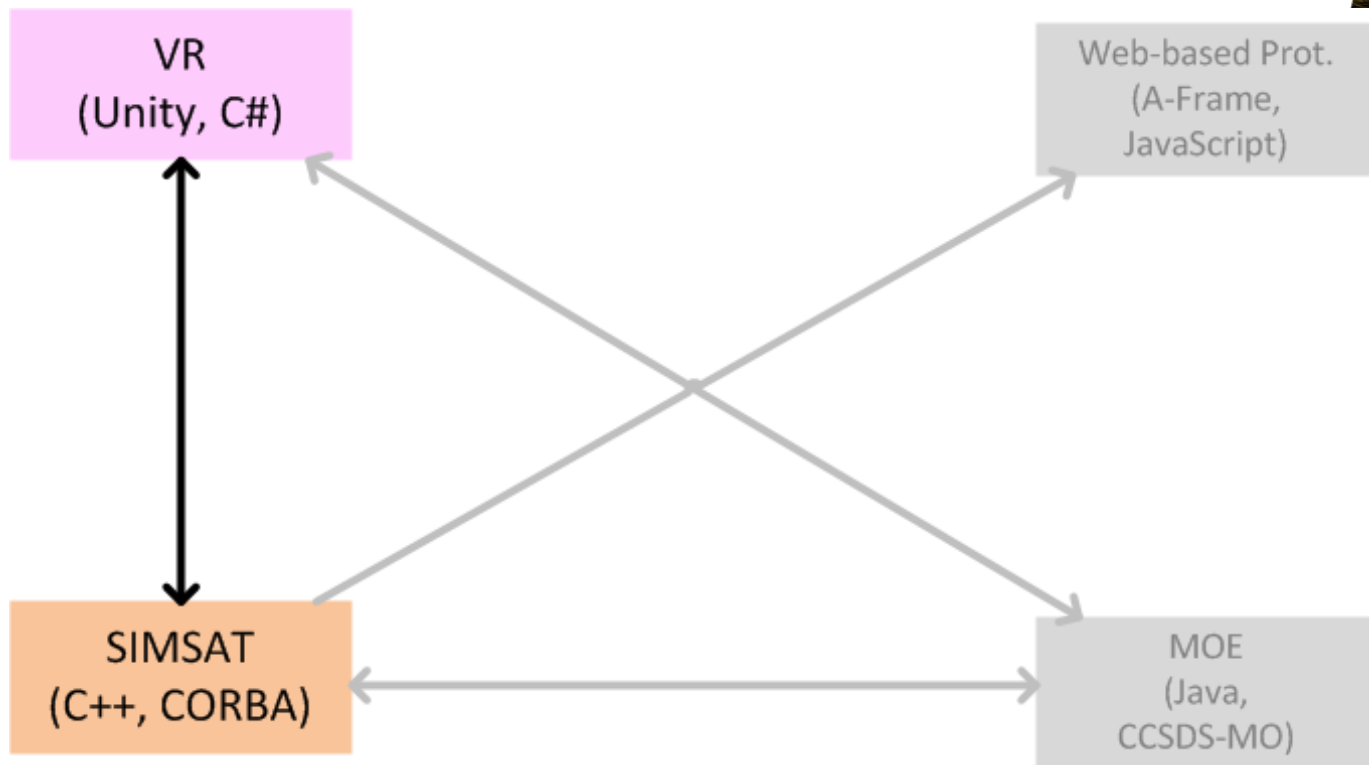


Integration of AR/VR with ESA Software

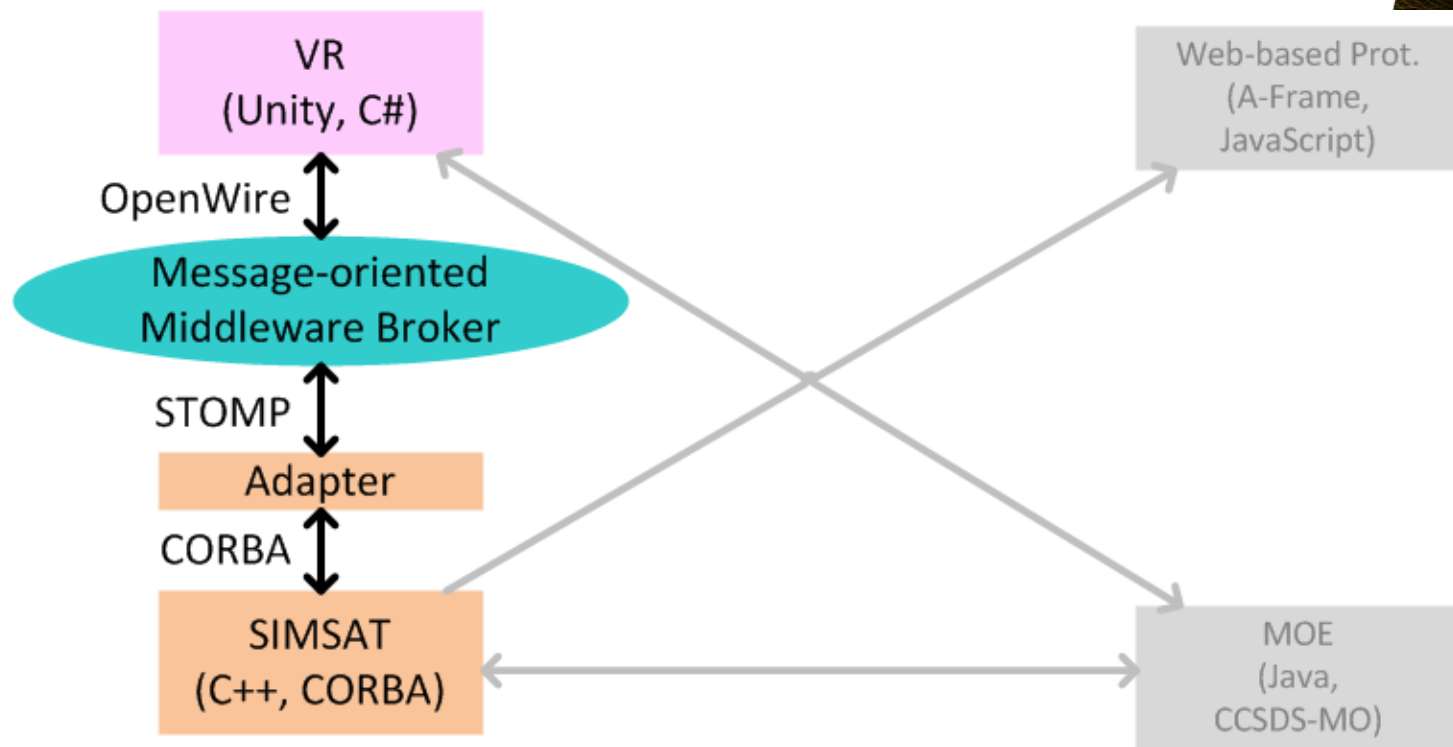
- Virtual Reality (VR) Study



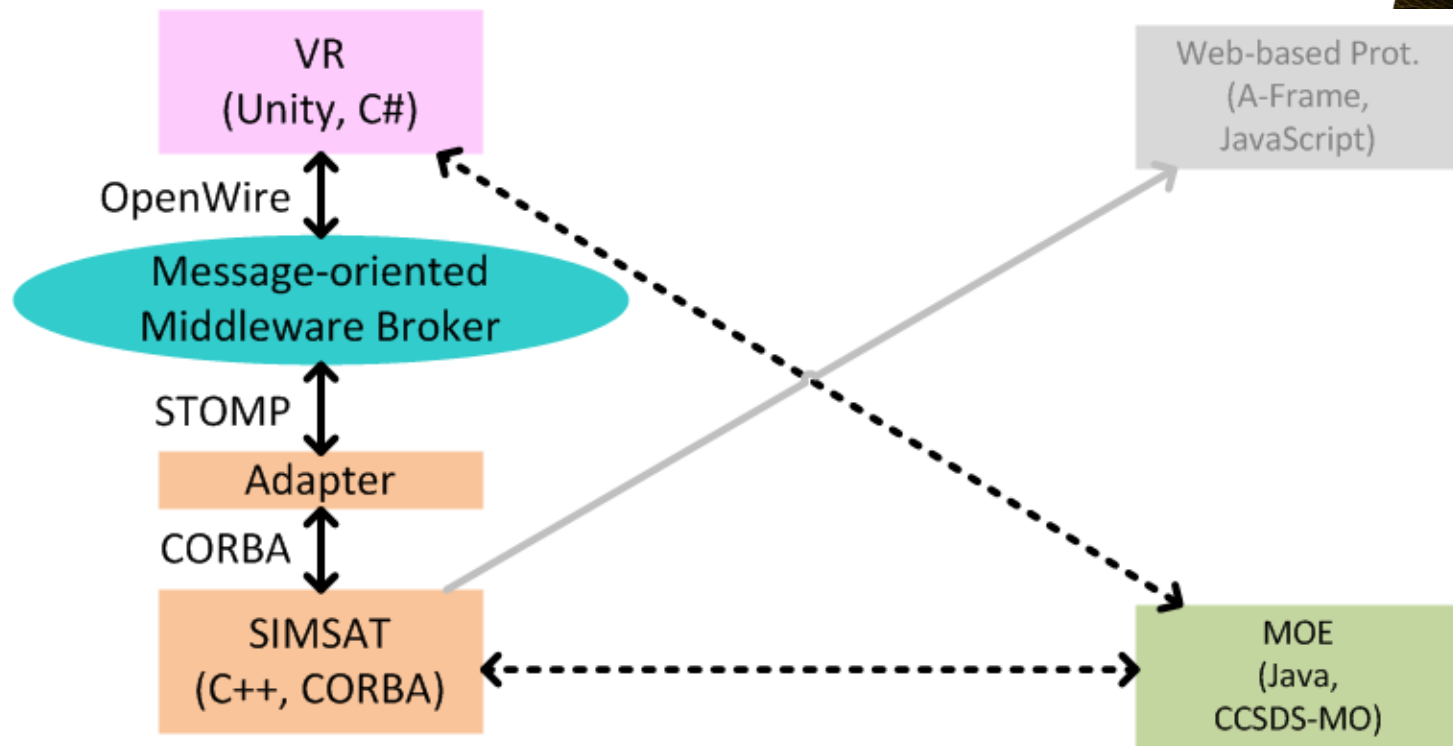
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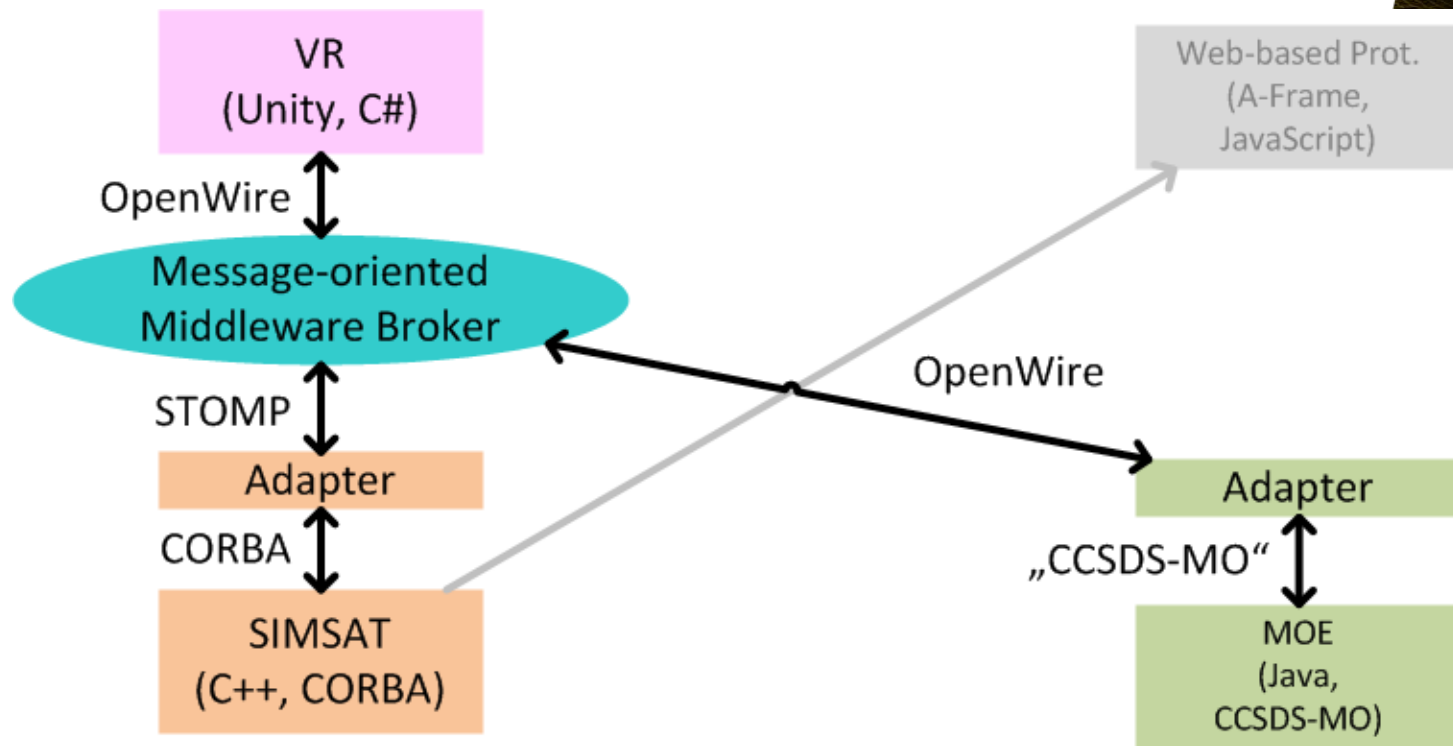
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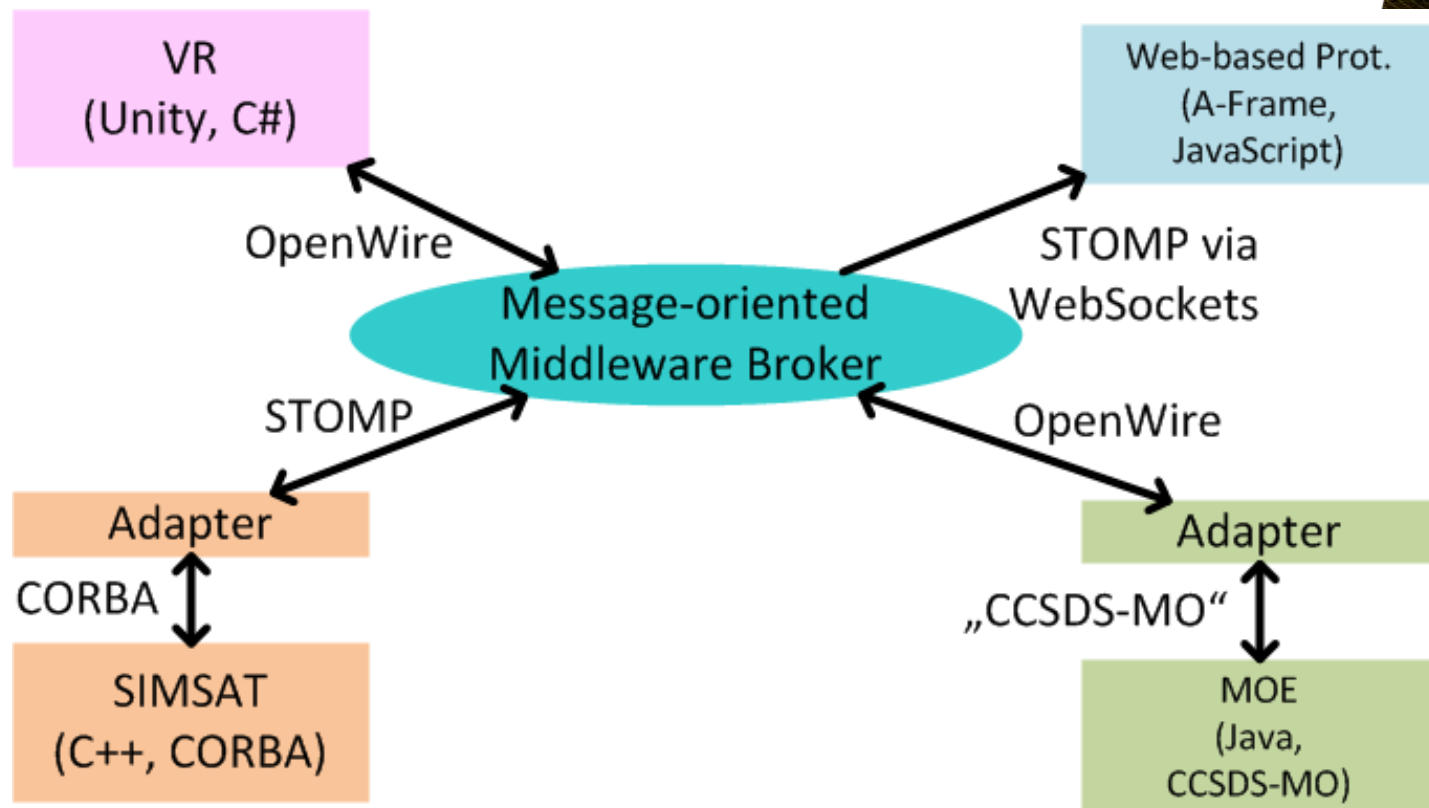
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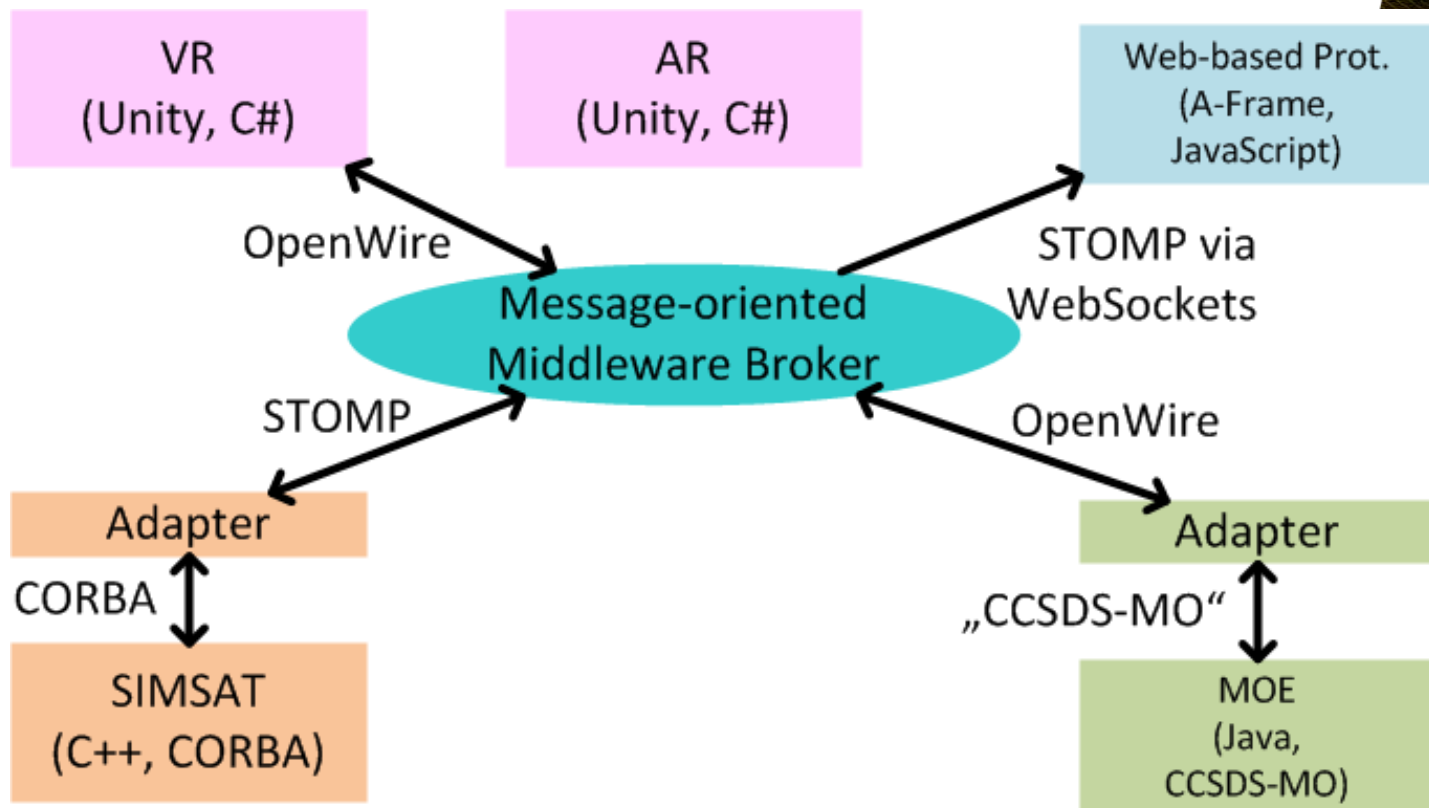
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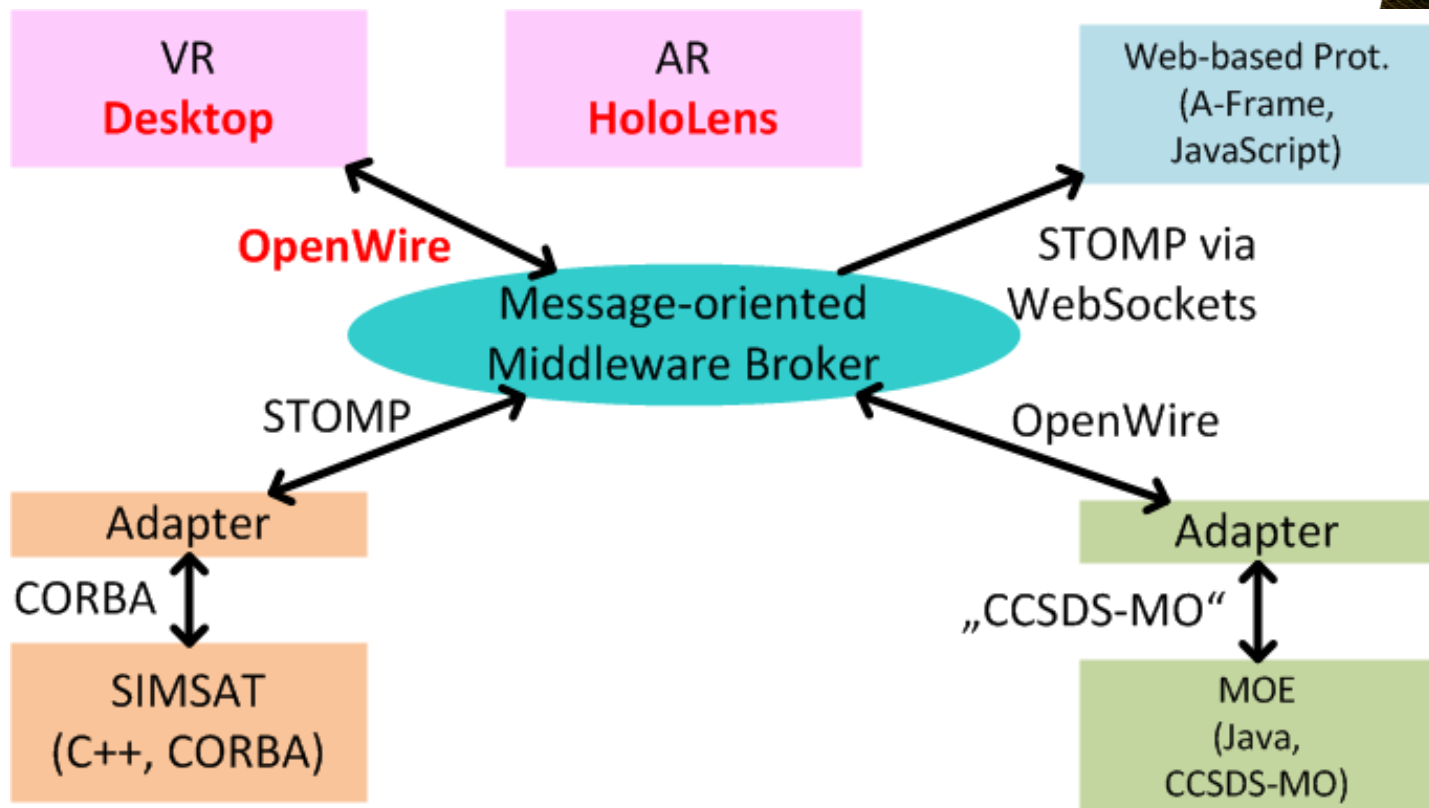
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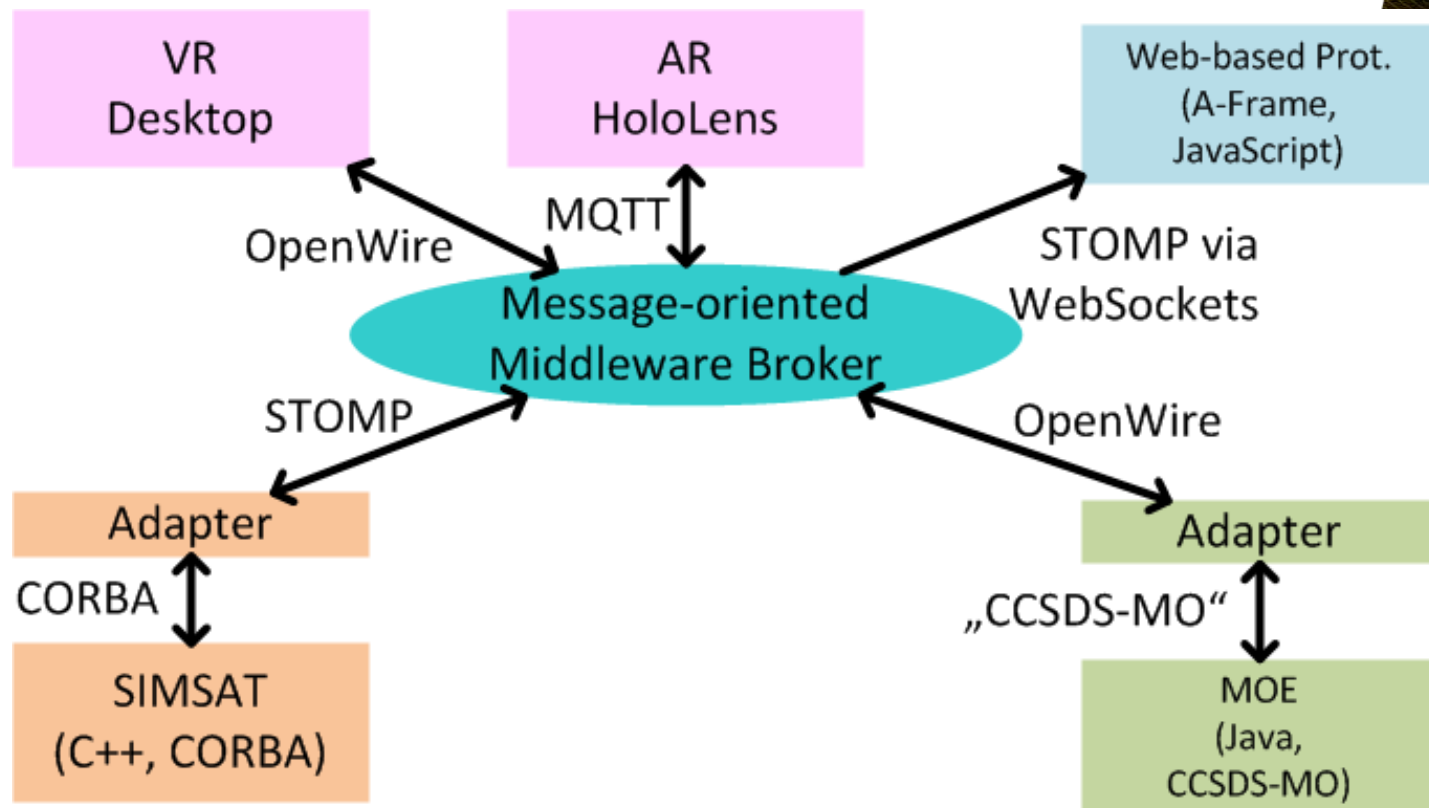
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Integration of AR/VR with ESA Software

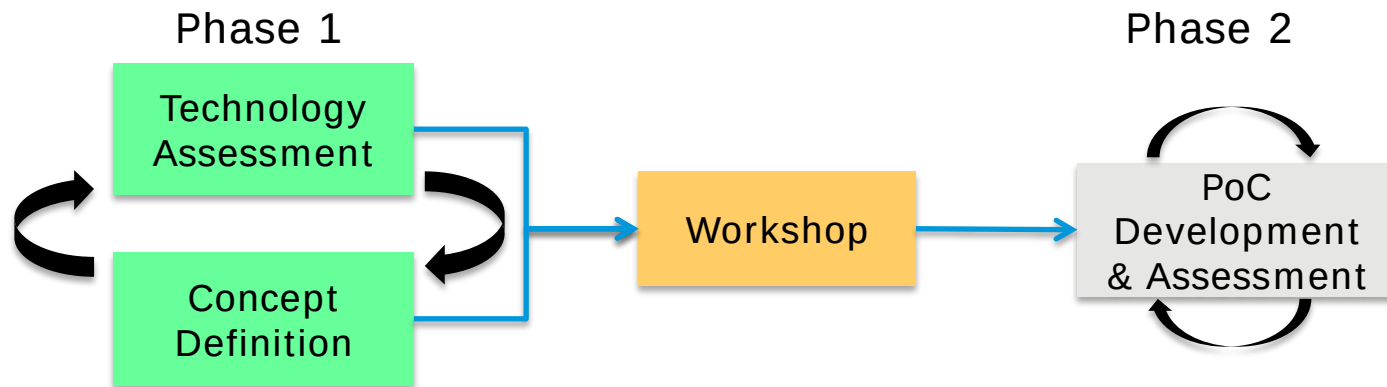


Integration of AR/VR with ESA Software



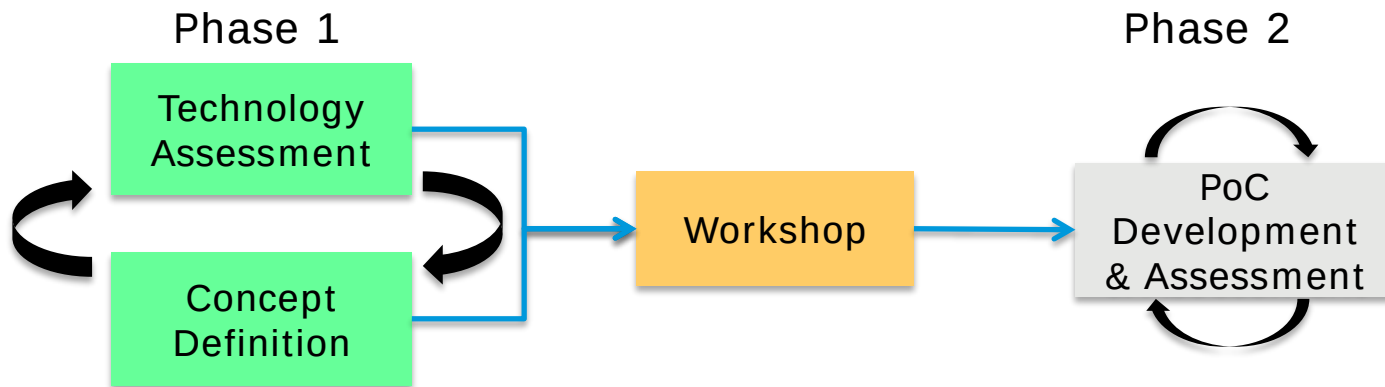
Agile-like Workflow/Development Processes

- Concept Definition (Use Cases / Applications)
- Technologies & Integration Assessment
- Practical Assessment
 - -> Proof of Concept (PoC)



Agile-like Workflow/Development Processes

- Concept Definition (Use Cases / Applications)
 - “Open”: Broader Scope than the PoC
- Technologies & Integration
 - VR/AR & ESA Systems
- Practical Assessment -> Proof of Concept (PoC)
 - Selected Use Case(s)

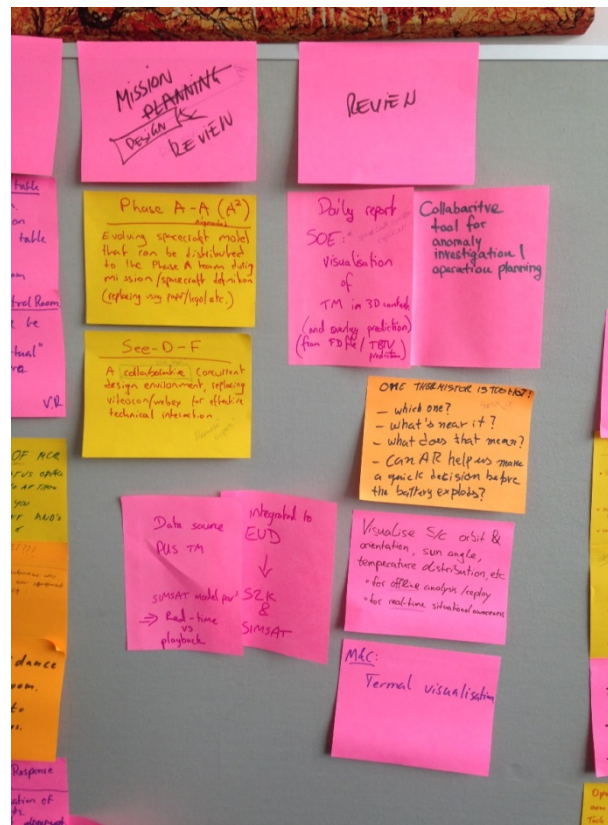
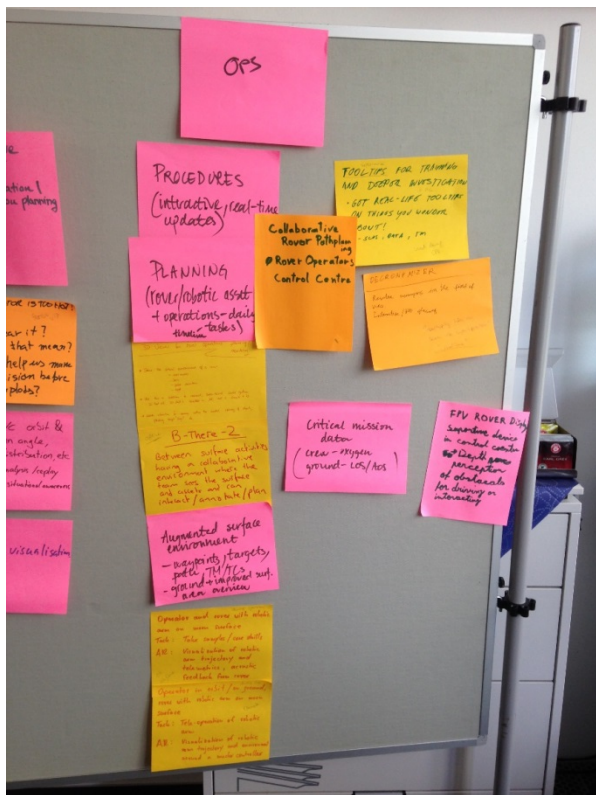


Use Case Identification and Details Development



- Interviews/Mini-workshops
 - Two Parts
 - Ideation
 - High-level Ideas for Application Scenarios
 - Derivation/Definition
 - More Details about (Selected) High-level Application Scenarios
 - “Open”
 - Broad Scope
 - Not Limited by PoC Considerations
 - **A Basis for Future Activities**

Ideation “Raw” Results Examples



Application Scenario “Taxonomy”



- Application Domain
 - Mission Control
 - Robotic Operation
 - Virtual Lunar Base (EVA)
- Goal of the Scenario
 - Training
 - Planning
 - Operations
- ...

High-level Scenarios

- Training
 - Interactive Training/Manuals
 - Virtual (AR) Representation of Training Instructions/ Manual
 - Interactively show procedures/steps.
 - Overlay instructions with real world.



High-level Scenarios (Continued)

- Planning
 - Rover Operations Planning
 - AR Scene with Rover & Environment
 - Scientists Mark
 - Operators Plan
 - Managers Verify
 - Multi-user?



High-level Scenarios (Continued)

- Operations
 - Spacecraft Operations
 - Analyse Situation
 - Plan Next Steps
 - Multi-user?



- ESA UNCLASSIFIED - For Official Use

End



Thank you very much for your attention.

Questions?

Ruediger Gad for the VR & AR Study Teams

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